The Belle Hall Plantation Charrette:

An Analysis of Stormwater Runoff Differences
Between Traditional and Sprawl Development Scenarios

Introduction

The Greater Charleston, South Carolina area is well known for its rich cultural heritage and abundant natural resources. This region, which is comprised of Berkeley, Charleston, and Dorchester counties, has experienced steady growth since the founding of the City of Charleston in 1670. The intricate system of waterways that are located within the Charleston Harbor watershed (Wando, Ashley, Cooper, Stono, and North Edisto Rivers) have contributed greatly to the region's past and will play an integral role in its future. The Harbor is what first attracted settlers to this area. A port soon followed, which today is one of the largest on the East Coast. Fort Sumter, the site of the first shots of the Civil War, lies in the center of the Harbor and is a popular tourist attraction. Tourists and locals especially enjoy fishing and shrimping in the Harbor, two important aspects of the region's economy. The Charleston Harbor is an essential part of the "Lowcountry" way of life: oyster roasts in the fall and winter and sailing regattas in the summer.

The tri-county area was one of South Carolina's fastest growing regions from 1970 to 1990 and that trend is expected to continue over the next twenty years. In fact, Dorchester and Berkeley counties are two of the state's fastest growing counties. Charleston County is already one of South Carolina's most urban counties. The region's population was 506,000 in 1990 and it is projected by the Berkeley, Charleston, Dorchester Council of Governments (BCDCOG) to be 739,000 by 2015, despite the closure of the Charleston Naval Base. This population growth, with its increased demand for infrastructure and development, can have a negative impact on the watershed's natural and cultural resources. More roads and housing will be necessary which means likely conversion of land from forests to urban/built up land. Point source discharges from industries supplying needed jobs and from municipal plants treating more wastewater from new area residents, can be expected to increase. These types of activities can affect critical biological habitats.

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In 1989, local citizens realized that with the opening of Interstate 526 (the Mark Clark Expressway) more land would be accessible, and therefore more likely to be developed. After seeing what had happened in other urbanizing estuaries when growth was not planned for properly, the public became concerned about what could happen in Charleston. They formed a citizens' group to examine the issues surrounding growth in the area. In 1991, the National Oceanic and Atmospheric Administration provided funding to the South Carolina Coastal Council (state government restructuring has now placed this agency within the South Carolina Department of Health and Environmental Control as the Office of Ocean and Coastal Resource Management SCDHEC/OCRM) to develop a Special Area Management Plan known as the Charleston Harbor Project (CHP). The CHP's goal is to maintain and enhance the water quality of the watershed while preserving its rivers' many uses and acting on potential problems before they adversely impact the harbor system.

Over the course of the last five years the CHP has conducted over 50 studies focusing on issues concerning growth and its impacts on the watershed's natural, cultural, and economic resources. These studies deal with topics ranging from land use, recreation and stormwater runoff to water quality modeling, cultural resources planning and the identification of **critical** biological habitats. The results of these studies will form the basis for policy development of the comprehensive management plan for the Charleston Harbor watershed.

The CHP created twelve task forces, revolving around topics related to the health of the Charleston Harbor watershed. The Land Use Task Force was responsible for a project which directly involved managing stormwater from different development scenarios. Many members of this task force, which is comprised of municipal and county planners, developers, regional planners, environmental interests, and other interested parties, agreed that the traditional town development pattern, which is the way most communities were built prior to World War 11, would be better for lasting stormwater runoff impacts as opposed to the now prevalent sprawl method. This theory, however, had not been proven. In order to present "neotraditional" planning concepts to local decision makers, such proof would be needed in order to make a justifiable case for altering the status quo of development practices in the watershed. Therefore, the CHP decided to test the two scenarios against each other and examine the results for stormwater runoff. This was a step which would need to be taken in order to have truly integrated management of the watershed as an estuarine system. A planning exercise to develop the two patterns, known as a charrette, was conducted to design the scenarios to be tested.

Neotraditional Planning Concepts as Part of Integrated Watershed Management

Neotraditional planning concepts can help to wisely assimilate population growth into a watershed while keeping impacts to its resources to a minimum. The debate over the negative impact of conventional development often pits developers and public officials on opposite sides of the argument. The public interest decries the damage that has been done to sensitive land areas and fragile natural resources, the increasing pressure on services and facilities created by uncontrolled sprawl, and the spiraling cost of transportation and utilities infrastructure. The private sector, on the other hand, responds to existing needs for housing and commercial development using the time-proven formula of accessibility by major highway, low land cost, and product to meet the purchasing power of the market. The public sector, represented by local planning organizations, has gradually become reactive rather than proactive in responding to proposals, instead of setting direction for future growth.

The approach that was sought in the charrette was to understand the needs of the private sector, but at the same time, explore ways in which their objectives may be accommodated while shifting the physical patterns in a direction more conducive to cohesive neighborhoods and communities, less movement stress, and more integration of land uses.

Concepts

The concept of "town" is one that has made a comeback in the consciousness of planners and designers over the past few years. The idea of higher densities and mixed uses is being reassessed as an alternative to the prevailing low densities and land use segregation that have typified suburban expansion in recent decades. More communities are now willing to explore change in their development patterns and the regulations that guide and control physical growth in their jurisdictions.

With this in mind, the charrette for the Belle Hall property sought to explore a scenario significantly different from today's development practices in Mount Pleasant. This area, which is increasingly subject to growth pressures as part of the greater Charleston metro area, is characterized by fragmented low density sprawl with no clear structure and little sense of direction. Highway 17 North acts as the only element that ties growth in the area with the resulting corridor pattern that depends exclusively on one collector to cover large volumes of intra-city traffic. Each new development occurring along this arterial attempts to be exclusive and detached, focusing inwardly on internal amenities that create their own micro environment with little regard to connectivity or to the larger sense of community. This is not unique to Mount Pleasant. Decades of corridor development and subdivision sprawl have effectively destroyed the cohesiveness that towns once had before the proliferation of car ownership among American families. Planning legislation simply followed the trend and provided a legal foundation to the desire of the new suburbanites to be segregated from other non-residential uses, and furthermore, to be isolated from extraneous traffic of any kind. This can be seen everywhere along the Mount Pleasant bypass. The Belle Hall property, which is adjacent to the Mark Clark expressway, is beginning to be engulfed by this kind of development. Because of the nature of the terrain in this part of the coastal region, typified by low elevations,

wetlands, and poor drainage characteristics, overlaying it with conventional, low density development, poses critical problems relative to sensitive land protection and water quality. Alternatives should be analyzed in order to protect water quality and the overall ecological health of the estuary.

As long as a community is willing to pay the price of low density development, very little will happen to offset the prevailing bottom-line driven formula for the development of land. This conventional approach has basic concepts that override other considerations:

- Utilize the maximum possible percentage of land surface

- Subdivide into the maximum number of lots that the property can yield

- Concentrate on quality of individual units at the expense of quality of open areas and community facilities.

While it may not be the intent of these concepts to omit development alternatives, these concepts have become so prevalent that alternatives are no longer considered in the design process.

The challenge of the charrette was to explore alternative schemes that would accomplish the same goals of today's development industry while reducing the negative impact of sprawl on sensitive lands, water quality, and infrastructure cost. Several schemes were designed and analyzed in terms of environmental quality, sense of place, community structure, and ability to function with lesser dependence on the automobile. The issue of stormwater runoff was a variable considered in all schemes.

The Exercise

The urban design **firm** of Dover, Kohl & Partners in South Miami, Florida was selected to lead a charrette exercise which would develop the two scenarios to examine. A site in the Town of Mount Pleasant known as Belle Hall Plantation was selected to give the exercise a real location with real considerations to contemplate. Charrette participants include Town of Mount Pleasant and Charleston County planners, BCDCOG planners, SCDHEC/OCRM staff, private sector engineers, Dr. Elizabeth Blood of the Jones Ecological Research Center, graduate students earning degrees in city and regional planning at Clemson University under the direction of Dr. Jose Caban, and other interested parties. This was a three day process which started with the development of the "Sprawl scenario". The number of units in that scenario set the parameters for the "Town scenario". This was done to ensure an even comparison of the two designs. Dr. Blood then tested the results of the two scenarios using a water quality model.

Belle Hall Plantation is a 583 acre site in the Town of Mount Pleasant which is located near the Wando River. Mostly residential development is expected for the area above the Mark Clark expressway while the area below it will be more commercial and industrial due to its proximity to the State Ports Authority's Wando terminal. In 1990, the land use for the area was mostly evergreen and mixed forest with some scrub/shrub classifications. A small portion had already been developed as part of the current Belle Hall subdivision which borders the site. This data was used as the base land use with which the two scenarios were compared.

The Sprawl scenario was derived from several examples of developments in the area. The total number of units for this design set the parameters which would be used for the Town design. The Sprawl scenario contains mostly single family detached homes with some higher density housing in the northwest section of the property. There is also a "power center" commercial area which would house a large retail outlet and a grocery store. The area below the Mark Clark Expressway will be used for industrial purposes since it is near the Wando terminal. Rat Hall Creek is the receiving water body. *(See Diagram p. 5)*

The Town scenario was developed after analyzing areas of Downtown Charleston, the Old Village in Mount Pleasant, and Savannah, Georgia. The amount of residential, commercial, office and industrial space are the same as in the Sprawl scenario but the land uses have been organized differently. The lots are smaller and there are more mixed use areas. Residential densities increased, and residential and commercial land uses were blended together. For example, some of the commercial areas are two-story buildings with a store on the bottom and a residence on top similar to those found in downtown Charleston. The streets are not as wide which encourages more pedestrian traffic and less reliance on the automobile for making trips to the comer grocery store. Also, the grid street pattern provides drivers with several options to reach their destination instead of waiting to connect to one major road. This scenario leaves most of its land in a natural state. This preservation of open space is good for natural habitat protection, particularly for herons and osprey in the area as they roost and nest. This design also would be less expensive to build because there would be less land to service, meaning less infrastructure requirements. *(See Diagram p. 6)*

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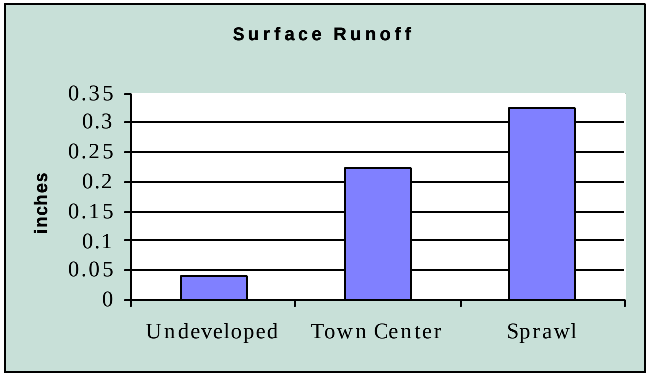
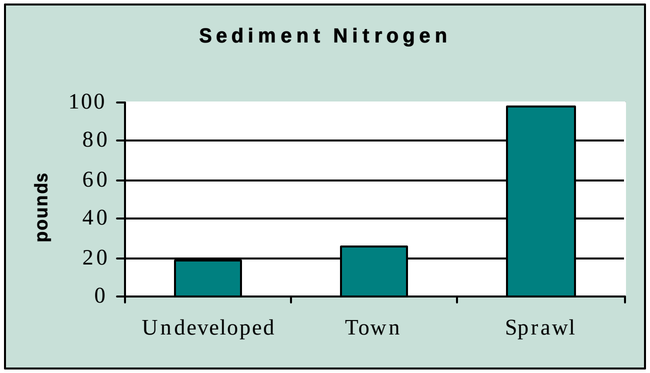
The Modeling

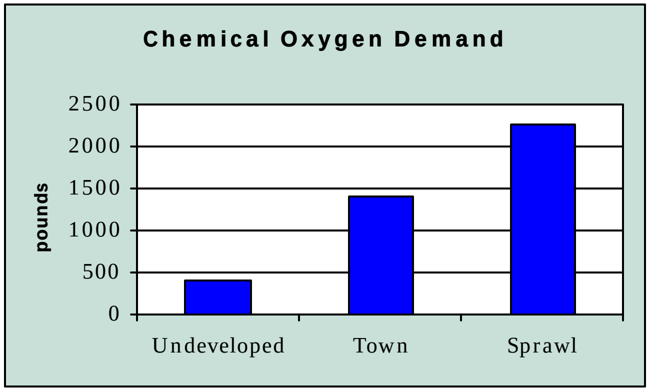
Dr. Blood ran these two scenarios through a GIS stormwater model, which was adapted for the Charleston Harbor and is being developed as a part of a water quality model the CHP is developing for the Charleston Harbor watershed. The particular nonpoint source model used for this exercise was Agricultural Non-point Source 3.65 (AGNPS). It was originally developed by the Minnesota Soil Conservation Service, Minnesota Pollution Control Agency, USDA Agricultural Research Service and the US Soil Conservation Service. The model has received extensive testing during development on over 20 different watersheds. This is a distributed-parameter model which divides watersheds into individual cells. The model uses the SCS curve method to predict single runoff events and a modification of the Universal Soil Loss Equation to predict sediments, chemical oxygen demand, nitrogen and phosphorus loads. Water is routed from the most distant point in the watershed to the outlet based on user defined hydrologic flow paths. The Universal Soil Loss Equation requires site-specific information on drainage characteristics, soils, land use, and topography. The spatial data used to determine input parameters for each cell were provided from a GIS database of Charleston Harbor. The necessary parameters were entered for each cell and output is calculated in each cell and routed through the watershed according to topography.

Three scenarios were evaluated: Undeveloped (1990 land use), Town development and typical Sprawl development. For the undeveloped watershed, 1990 land cover and land use information, STATSGO soils data and topographic hydrologic routing were used to develop parameters for AGNPS 3.65. In the developed scenarios, undeveloped land was parameterized using the undeveloped scenario data. Land use for the developed areas were based on the Town or Sprawl development plans provided by Dover and Kohl. The hydrologic flow paths were modified in the developed areas to reflect street drainage patterns and storm detention ponds. Model coefficients were modified to reflect the types and density of urban development. Coefficients were modified to incorporate the amount of impervious surface area in the developed areas. Nutrient loads calculated by the model are conservative as no fertilizer applications were assumed. Detention ponds were modeled according to stormwater regulatory guidelines.

Land development increased the amount of surface runoff, sediments, nutrients and chemical oxygen demand entering the surface waters of Rat Hall Creek. Results of the analyses are provided in the graphs on the following page. Hydrologic rerouting to reflect storm drains and the increase in impervious surfaces resulted in greater peak flows and the location in the watershed where the peak flows occurred. The Sprawl scenario had eight times greater runoff than the undeveloped watershed and was 43 percent higher than the Town scenario. Much larger differences between the two development scenarios were determined for sediment loads. The Sprawl scenario had three times greater sediment loads than the Town and ten times greater sediment loads than the undeveloped watershed. Vegetated areas (e.g. green space, undeveloped land) were important in reducing sediment loads transported to the watershed outlet. Similar results were obtained for sediment nitrogen and phosphorus. Chemical oxygen demand (COD) is an indicator of the potential oxygen stress entering surface waters. These compounds upon entering surface waters can reduce the oxygen available to aquatic biota. The highest average watershed concentrations and total watershed loads were associated with the Sprawl scenario. However, if one considers only the comparable developed areas within the watershed, the Town scenario had higher COD loads than the Sprawl scenario. In comparable developed areas, the Town had the highest urban density and the highest percent impervious areas of all alternatives considered. This means careful consideration must be given to the location of the most densely populated areas in the Town scenario. If they are located away from the receiving water body the open space between that area and the water body will reduce the actual loadings entering the water body.







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These initial analyses indicate that the type and density of development alter the hydrology and the concentration and total quantity of non-point source sediment, nutrient and oxygen demanding substances entering coastal waters. Increasing impervious surfaces increased the impact. Altering hydrologic flow from topographic controlled flow paths and natural channel structure to storm drains, contributed to the increased water volume and non-point source loads observed. Surface waters that were routed through detention ponds and traversed vegetated areas had lower flows and reduced loads. Considerations should be given to maintaining green space, reducing the amount of impervious areas, location of high density development, and the incorporation of best management practices (e.g. detention ponds) to reduce the effects of urban development on coastal watersheds.

Regulations and Permitting Process:

Both scenarios were analyzed at a cursory level by the staff at SCDHEC/OCRM for stormwater regulatory compliance. Had these scenarios been actual developments more information would have been required before permits would have been issued. The analysis conducted by the SCDHEC/OCRM staff was done to make sure the designs would have a realistic chance of being permitted.

The existing regulations that would apply to the proposed designs are contained in the S. C. Stormwater Management and Sediment Control Handbook for Land Disturbance Activities. This handbook includes Section 72-300 which has the "Standards for Stormwater Management and Sediment Reduction" adopted by the division of DHEC that was previously called the Land Resources Conservation Commission. In addition, the handbook contains the requirements that are part of the Coastal Zone Management Program Refinements adopted in August of 1993. The stormwater permitting requirements of 72300 apply statewide and the OCRM Program Refinements apply in certain specific cases in the Coastal Zone. The location of the Belle Hall property involved in the charrette would include the application of some of the additional requirements in the OCRM Program Refinements. The applicable stormwater management requirements are as follows:

A. **Stormwater Runoff Storage Requirements**

The regulations of the Stormwater Management and Sediment Reduction Act require that "permanent water quality ponds having a permanent pool shall be designed to store and release the first 1/ 2 inch of runoff from the site over a 24-hour period. The storage volume shall be designed to accommodate, at least, 1/ 2 inch of runoff from the entire site." For all projects, regardless of size, which are located within one-half (1/ 2) mile of a receiving water body in the Coastal Zone, this criteria shall be storage of the first 1/ 2 inch of runoff from the entire site or storage of the first one (1) inch of runoff from the built-upon portion of the property, whichever is greater. In addition, for those projects which are located within one thousand (1,000) feet of shellfish beds, the first one and one half (1 1/ 2) inches of runoff from the built-upon portion of the property must be retained on site.

B. Water Quantity Controls

In addition to the storage requirements referenced above, the state regulations require that post- development peak discharge rates shall not exceed pre-development discharge rates for the 2- and 10-year frequency 24-hour duration storm event. Implementing agencies may utilize a less frequent storm event (e.g. 25-year, 24-hour) to address existing **or** future stormwater quantity or quality problems.

C. **Sediment/Erosion Control Requirements**

The regulations require that when stormwater runoff drains to a single outlet from land disturbing activities which disturb ten (10) acres or more then a sediment basin must be designed to meet a removal efficiency of 80 percent for suspended solids or 0.5 ML/L peak settable concentration, which ever is less. The efficiency shall be calculated for disturbed conditions for the 10-year 24-hour design event. Construction activities that have less than ten (10) acres of land disturbance draining to a single outlet may incorporate other practices besides a sediment basin to achieve the equivalent removal efficiency of 80 percent for suspended solids. Specific site conditions and/or topography may eliminate the need for removal efficiency calculations.

The estimated areas of impervious surfaces (for buildings, roads, parking lots, etc.) were used along with available topographic information to approximate the amount of pond areas that might be required to meet the regulations. Most of the developable areas on these tracts are within one-half mile of a receiving waterbody so the OCRM requirements from the program refinements for storage would have to be incorporated. There was no available information on the presence of shellfish beds, but this issue would have to be investigated prior to actual design of a stormwater management plan in the area to determine if additional storage requirements would be applicable.

It is difficult to make a prediction on meeting the post-development versus pre-development discharge requirements without additional information on pipe sizes, hydrograph routing, etc. In addition, without a full scale sediment/erosion control plan, meeting the 80% sediment removal efficiency requirement is hard to quantify. However, using general rule of thumb calculations it was established that with the amount and location of retention/detention ponds indicated for the town and sprawl scenarios, that the proposed developments could be in compliance with the necessary regulations. Using some of the stormwater ponds as sediment basins during construction would assist the developments in meeting the removal efficiency requirements. Overall, it appears that the stormwater systems presented for the CHP charrette scenarios, when incorporated with other best management practices, would be adequate in meeting the state and OCRM permitting requirements.

Development Cost Assessment

The issue of private cost versus public cost became one of the more interesting questions of this study. In addition to the quantifiable variables such as cost of land and construction, cost of infrastructure development, and other costs produced by environmental problems, there are social costs that play an equally important role, but that are much more difficult to measure. It is not hard to find fault in a place where a car trip is required to buy a candy bar, and one that turns parents into shuttle operators just to meet the basic needs of the family's daily life. But in more pragmatic terms, the study sought to attach dollar amounts to tangible elements of development, such as infrastructure components, and compare the cost we pay for sprawl as opposed to compact town development.

The study of cost variables revealed marked differences in the total cost of infrastructure for various scenarios using a variety of lot sizes ranging from 150' to 35' frontage. The analysis showed several dramatic comparisons, For instance, certain elements of infrastructure that would cost $7,000/unit in a sprawl scheme serving 272 units, would only cost $3,494/unit in a town scheme.

The table on the following page compares the average per unit cost of various elements of infrastructure for various lot sizes. Basic cost of selected items of infrastructure and site improvements were generated using current construction cost figures from the coastal area of South Carolina.

Comparing a 272-unit section of a town scheme to a section of a sprawl scheme the same size showed the following:

- The sprawl scheme contains 19,750 l.f. of streets.
- The town scheme contains only 9,850 l.f. of streets.
- The sprawl scheme would cost an average of $7,000 per lot for selected items of utilities and site improvements.
- The town scheme would cost only $3,494 for the same, roughly 50% of the cost of the sprawl scheme.

- The density of the sprawl scheme was 2.6 d.u./acre.
- A 214-acre site would accommodate 837 units on a town scheme approach.
- A 21 0 acre section of the sprawl scheme would carry only 333 units, or 40 percent of the town scheme.

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COST OF SELECTED ELEMENTS OF SITE DEVELOPMENT AND UTILITIES

Type of Development	24' Asphalt Pavement at $15.00/yd2 Avg./Unit	18' Concrete Curb & Gutter at $8.00/LF Avg./Unit	5' Wide Concrete Walk at $8.00/LF Avg./Unit	8" PVC Sewer 0'-6' deep at $16.00/LF Avg./Unit	8" PVC Water Line at $8.50/LF Avg./Unit	TOTAL PER UNIT	
Large Lots (150' x 200' = 30,000 s.f.)	$3,000	$1,200	$1,200	$1,200	$638	$7,238	
Medium Lots (100' x 200' = 20,000 s.f.)	2,000	800	800	800	425	4,825	67%
Narrow Lots (50' x 200' = 10,000 s.f.)	1,000	400	400	400	213	2,413	33%
Narrow Lots (50' x 100' = 5,000 s.f.)	1,000	400	400	400	213	2,413	33%
Row Unit Lots (35' x 150' = 250 s.f.)	700	280	280	280	149	1,689	23%
Section of Sprawl Scenario 272 Units - 19,750 L.F. of streets	$2,904	$1,160	$1,160	$1,160	$617	$7,001	
Section of Town Scenario 272 Units - 9,850 L.F. of streets	1,455	576	576	579	308 -	3,494	50%

The argument for more compact development can be made in terms of savings as compared to conventional development. It is clear that the cost of sprawl is significant, not just to the consumer, but to the public treasury that pays for extended utility infrastructure. Many planners and developers now maintain that the town scenario benefits, such as the cost savings and water quality improvements, can be obtained without negative impacts to marketability. In fact, examples of neotraditional development (such as Newpoint in Beaufort, SC) have outsold their competition. The same traditional neighborhood pattern that minimizes environmental damage also appears to offer other attractive benefits to householders, including the efficiency and sense of community which are often cited in buyer surveys.

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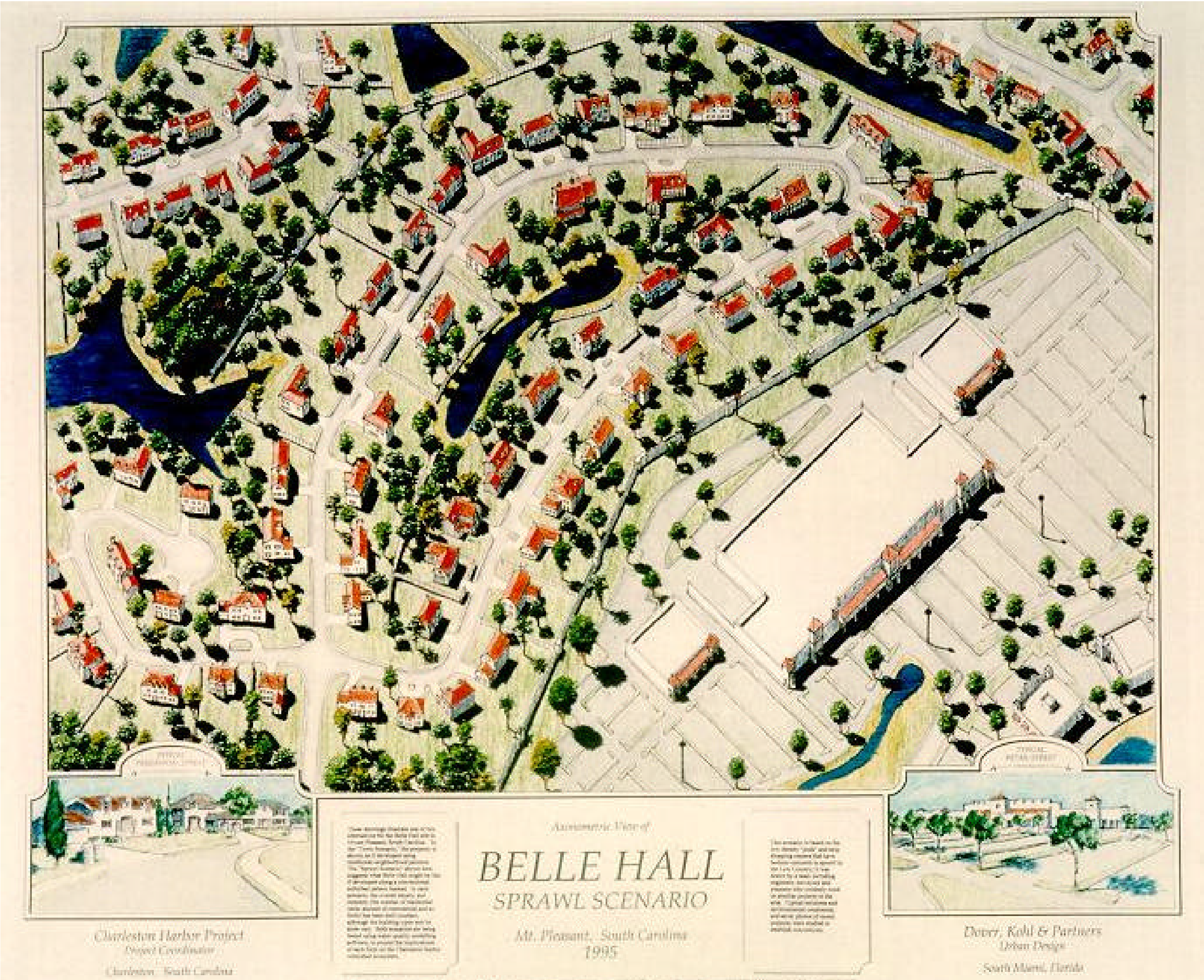
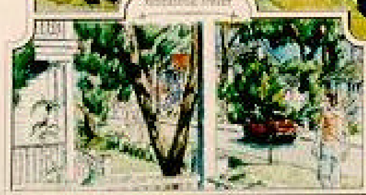
Conclusion

National and re-ional trends have indicated that coastal populations have increased over the past twenty years. This pattern of growing coastal populations is expected to continue, and this will affect the Greater Charleston area. The question for our area has become, how can we absorb this growth while maintaining the quality of life we have grown accustomed to and new residents expect to enjoy? Developments similar to the Town design can provide our area with the residential, commercial, and even industrial space that will be required to ensure a growing economy for the region. It can also lead to lower development and infrastructure costs. Consideration must still be given to the location of this type of development since there will be more concentrated impervious surface. If the most densely impervious areas of the design are located farther away from receiving water bodies, the benefits for stormwater management and water quality can still be realized. The real benefits of compact development also include protection of watershed resources, efficient use of the land for the public good, reduction in the number and length of car trips required of the average family, and generally in the creation of more humane living environments.

Site and layout drawings of the Sprawl versus Town designs of the Belle Hall Plantation development:


Axonometric View of
BELLE HALL
SPRAWL SCENARIO
Mt. Pleasant, South Carolina
1995
Charleston Harbor Project
Project Coordinator
Charleston, South Carolina
Dover, Kohl & Partners
Urban Design
South Miami, Florida



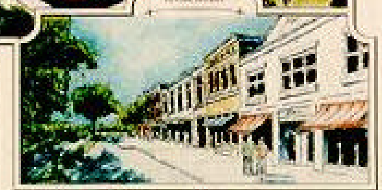
Charleston Harbor Project
Project Coordinator

Charleston, South Carolina

Axonometric View of

BELLE HALL
TOWN SCENARIO

Mt. Pleasant, South Carolina
1995



Dover, Kohl & Partners
Urban Design

South Miami, Florida